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Effect of Solar Radiation Intensity on the Vegetative Growth and Yield of Coffee.

By J. GUIscafré-Arrillaga and LUIS A. GOMEZ

A New Spinning Mite Attacking Sugar Cane in Puerto Rico.

By R. A. McGREGOR

The Occurrence of a Rare Genus of Ticks on Bats in Puerto Rico (Acarina: Spelaeorhynchidae)

By IRVING FOX

The Value of Filter Press Cake as a Fertilizer for Vegetable Crops. Preliminary Trials with Tomatoes and Cucumbers.

By ARTURO HOLLANG

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EFFECT OF SOLAR RADIATION INTENSITY ON THE VEGETATIVE GROWTH AND YIELD OF COFFEE

BY J. GUISCAFRÉ ARRILLAGA AND LUIS A. GÓMEZ

The Arabian type of coffee is generally grown under shade in order to obtain favorable growth and good quality of the bean. In those cases some species of leguminous trees are used to provide the shade. A study was undertaken in the year 1936 in order to measure the effect of different degrees of solar intensity on the growth and yield of coffee.

REVIEW OF LITERATURE

According to investigations on the effect of solar radiation on plants it has been shown that, in general, light tends to hasten maturation of plant organs and to produce a decrease in size. These effects vary in accordance with increasing intensity and under various sets of conditions. Bates (1) found that coniferous seedlings increased in size with increasing light intensity, while Briggs and Shantz (2) showed in crop plants, that the correlation ratio between radiation and transpiration varied from 0.65 to 0.48 and that, of the total radiation received an equivalent of 50 to 100 per cent was dissipated in transpiration and Shantz (12) found that there was an increase in fresh weight as the light intensity was decreased from 100 to 50 per cent of full sunlight. Shading caused a decrease in the dry weight of soybeans according to Garner and Allard (3); reduced flowering of apple trees as shown by Gourley (4); and caused an increase of leaf area in peaches (Gourley and Nightingale (5)). Hartley (6) reported injuries of high sunlight to coniferous seedlings; Korstian (7) found it favorably affected development of Douglas fir and Engelmann spruce; Shirley (13) reported it favorably affected growth of loblolly pine and redwood seedlings; and Popp (11) reported it caused

twining of bush and lima beans but unfavorable effect on growth of soybeans. Shade plants showed a considerable increase in chlorophyll concentration with decreasing light intensity while sun plants showed approximately the same chlorophyll concentration at all light intensities, according to Lubimenko (8). McClelland (9 and 10) compared artificially shaded plants with plants of the same varieties grown under full sunlight. He observed differences between the shaded and unshaded plants as pronounced as varietal differences in plants grown under uniform conditions. High yields were obtained under full sunlight, but the life of the tree was shortened substantially. Under 1/2 and 1/3 sunlight exposures the yields were lower but growth was apparently normal.

Materials and Methods

In the year 1936 a homogenous one-acre piece of flat land of the Catalina soil type, 150 feet above sea level was selected in the grounds of the Puerto Rico Agricultural Experiment Station (U.S.D.A.) at Mayagüez, Puerto Rico for our study. A lath frame (Figures 1 and 2)

Figure 1. *General view of the lath frame.*

20 feet high and of a total area of 28,900 sq. ft. was divided into 16 equal sections of 1,806.25 sq. ft. each to provide four different sunlight intensity

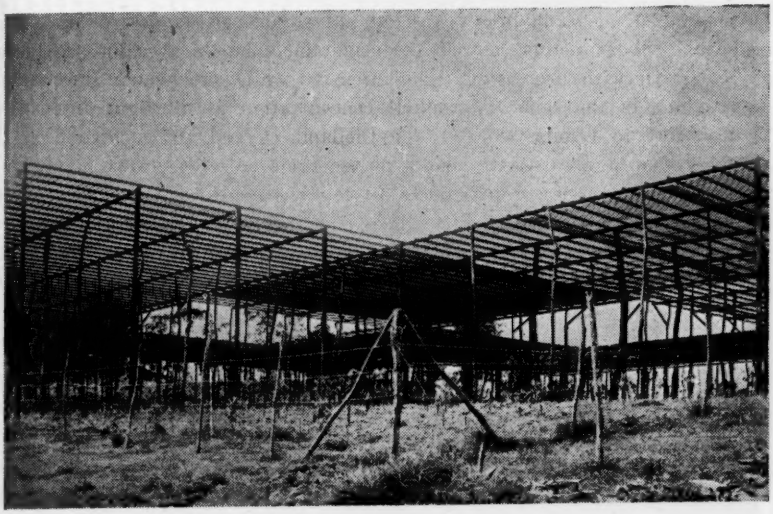

FIGURE 2. *Close view of the lath frame showing several different sunlight admitting sections or treatments*

treatments replicated four times and arranged according to a 4 x 4 Latin square lay-out.

The laths in the four different treatments were so spaced as to provide approximately 2/3, 1/2 and 1/3 solar radiations. Four sections were left uncovered as checks to provide full sun exposure. Coffee was planted at distances of 8 x 8 ft., each plot containing 25 trees. Of these only nine coffee trees in the center of each plot were regarded as the experimental plots. Two rows of trees surrounded every experimental plot. Thus, the experimental plots were separated by a strip of land 16 feet wide. This was done to avoid as much as possible the effect of one treatment on another. The coffee trees were grown under ordinary cultural practices including an application of commercial fertilizer of the formula 15-5-15, at the rate of one-half pound per tree during the last 2 years of the experiment.

The solar radiation under every treatment was recorded by four sets of Leeds and Northrup Micromax Recorders and Eppley's Weather Bureau type Pyrheliometers (Figure 3). These records were integrated with a planimeter. Growth measurements of height, lateral branching and trunk diameter were recorded at definite intervals. Yield of coffee was recorded

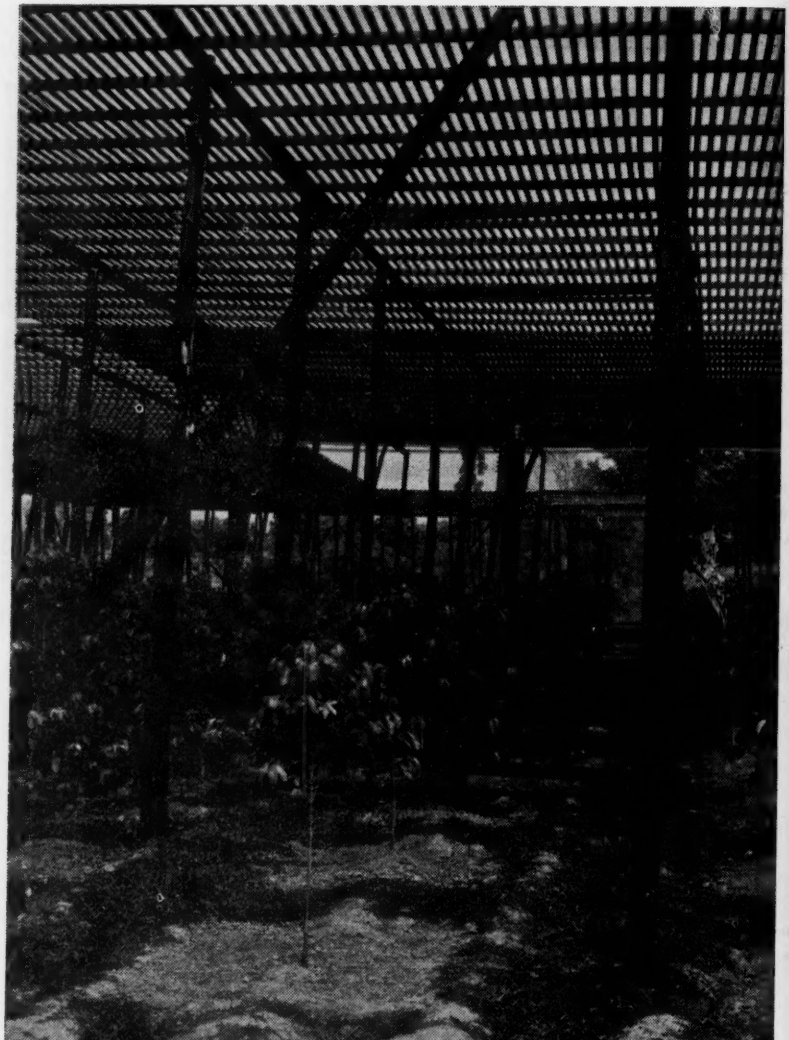

FIGURE 3. *Close view of the one-half sunlight treatment showing details of construction and disposition of the pyrheliometers under the various treatments.*

in pounds of beans. The relative humidity and temperature on every treatment was recorded by J. P. Friez Hygrothermographs. Soil samples were taken monthly from every plot to determine soil moisture. Outbreaks of leaf miner attacks and other insect pests were kept under control.

Experimental Results

In table 1, a complete record of the solar radiation for the experiment is given covering the period of June 1938 to May 1941.

Wide fluctuations in solar radiation. According to table 1, there is a wide fluctuation in the solar radiation recorded during different years. Under full exposure, 134,904.30 gr. cal./cm^2 were recorded for 1938, 158,081.70 for 1939, and 141,277.20 gr. cal./cm^2 for 1940. The fluctuation within any one year was even greater, for example, the radiation for the month of June 1938 was 13,031.40 gr. cal./cm^2 while for the month of November it was 8,933.70 gr. cal./cm^2. For all years the greatest intensity was recorded during the months of June, July, August, September, and the lowest during December, January and February.

Although the laths were arranged to provide 2/3, 1/2 and 1/3 radiation, the amounts recorded do not correspond exactly to these figures but to 55, 37, and 22 per cent respectively, of full sunlight. The reason for this is that during the first three hours of sunlight after sunrise and the last three hours previous to sunset all treatments are equally affected due to the angle of the sun's rays. It was from 10:00 A. M. to 3:00 P. M. that the various treatments received 2/3, 1/2 and 1/3 sunlight intensity since during this period the sun's rays are almost vertical. However, it is during this period that sunlight reaches its optimum intensity.

Shade tends to reduce annual fluctuations in radiations. While under full sunlight there is quite a wide fluctuation in solar radiation from year to year; 134,904.30 gr. cal./cm^2 for 1938; 158,081.70 for 1939 and 141,277.20 for 1940; during the same years for 2/3, 1/2 and 1/3 radiation fluctuates between 76,542.60 and 83,687.10; 51,569.10 and 54,485.70 and 29,608.80 and 32,699.60 gr. cal./cm^2, respectively.

Decrease in solar radiation increases growth and yield of coffee. Considering the average for three years, the trees under one-third and one-half radiation produced crops significantly superior to the trees under two-thirds and full radiation. The average yields in pounds of market coffee for 3 crops under one-third and one-half radiations was 28.77 and 24.13

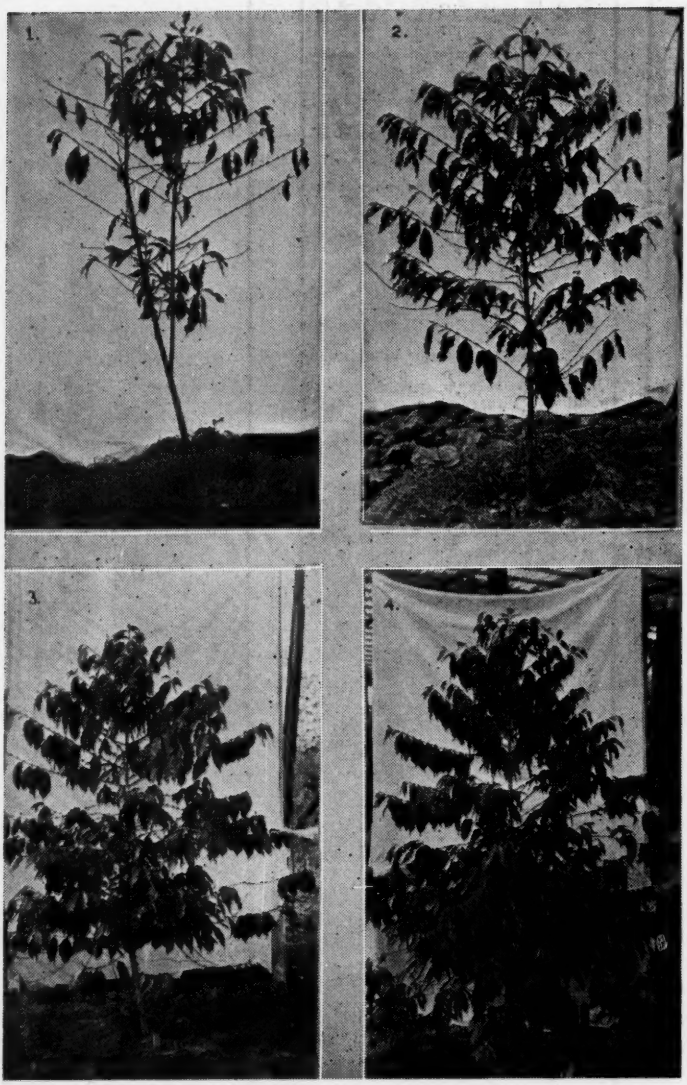

FIGURE 4. *Growth conditions of coffee trees under various solar radiation intensities: 1, under full sunlight; 2, under ⅔ sunlight; 3, under ½ sunlight; 4, under ¼ sunlight.*

TABLE I. *Total solar radiation recorded at Mayagüez, Puerto Rico, at the experiment from June 1938 to May 1941 under various exposures (Gram calories per square centimeter).*

TABLE I. *Total solar radiation recorded at Mayagüez, Puerto Rico, at the experiment from June 1938 to May 1941 under various exposures (Gram calories per square centimeter).*

MONTHS	1938 - 1939				1939 - 1940				1940 - 1941			
	FULL	2/3	1/2	1/3	FULL	2/3	1/2	1/3	FULL	2/3	1/2	1/3
June	13,031.40	6,960.30	5,867.70	2,713.20	12,450.30	7,569.00	4,760.40	3,062.70	10,269.60	7,224.60	4,267.20	3,187.10
July	11,887.20	7,465.20	4,823.40	2,816.70	13,883.70	7,728.90	4,638.00	3,100.80	12,486.00	7,719.60	4,578.90	3,397.20
August	11,442.90	7,057.20	5,538.90	2,760.00	14,630.70	8,144.40	4,876.80	3,267.30	13,243.80	7,385.10	4,504.50	2,927.40
September	11,498.40	7,001.70	4,753.20	2,631.90	14,382.90	8,006.40	4,794.30	3,212.10	12,321.00	7,026.00	5,318.70	2,704.50
October	12,085.50	6,941.70	4,894.20	2,817.60	14,714.10	8,181.00	4,904.70	3,285.90	10,735.20	5,270.10	4,005.30	2,262.30
November	8,933.70	4,641.90	3,708.60	2,084.70	11,153.40	5,709.90	3,728.10	2,534.10	10,053.90	4,469.10	3,735.60	2,136.30
December	9,027.30	4,638.90	3,599.10	2,165.10	10,886.70	4,837.20	3,318.00	2,508.30	9,203.70	4,719.90	3,347.10	2,328.90
January	9,098.10	4,762.50	3,803.40	1,837.20	10,888.50	5,099.10	3,736.80	2,167.50	9,094.80	4,639.20	3,598.80	1,884.90
February	10,604.70	5,827.80	4,102.20	2,213.40	12,293.40	6,219.90	4,489.80	2,513.10	12,054.00	5,956.50	4,823.40	2,550.90
March	12,358.80	7,120.50	4,173.90	2,665.50	13,786.20	6,855.00	4,845.90	2,859.00	13,240.80	7,289.40	3,446.40	3,159.60
April	13,048.80	6,978.00	4,847.10	2,483.10	14,910.30	7,950.90	4,975.20	3,045.90	14,142.00	8,023.80	5,056.50	3,278.10
May	11,887.50	7,146.90	4,374.00	2,420.40	14,101.50	7,385.40	4,306.80	3,019.50	14,432.40	7,912.20	4,886.70	2,882.40
All months	134,904.30	76,542.60	54,485.70	29,608.80	158,081.70	83,687.10	53,374.80	34,576.20	141,277.20	77,635.50	51,569.10	32,699.60

Average for three years:

Full	144,754.40
Two-thirds	79,288.20
One-half	53,143.20
One-third	32,291.54

Greatest and lowest intensity recorded in gram calories per minute per square centimeter.

YEARS	FULL	2/3	1/2	1/3
1938-39	1.88 - 1.51	1.71 - 1.16	1.54 - 1.09	1.42 - 0.92
1939-40	1.88 - 1.35	1.59 - 1.08	1.51 - 1.08	1.40 - 0.81
1940-41	1.91 - 1.68	1.71 - 1.15	1.61 - 1.14	1.45 - 0.85

in comparison to 17.00 and 9.29 pounds for the same period under two-thirds and full sunlight, respectively. (Table 2).

The maximum and minimum intensities vary for the 4 exposures. The maximum intensity recorded under full sunlight was 1.91 gr. cal./ min./ cm.^{2} while the minimum was 1.35 gr. cal. min./ cm.^{2}. The maximum under 1/3 sunlight was 1.45 and the minimum 0.81 gr. cal./ min./ cm.^{2}. The maximum under 2/3 was 1.71 and the minimum 1.08 while the maximum under 1/2 sunlight was 1.61 and the minimum 1.08 gr. cal./ min./ cm.^{2}.

The differences in yield between trees under one-third and one-half radiations and full exposure were highly significant. These results do not agree with those of McClelland (9 and 10) who obtained higher yields from trees fully exposed to sunlight.

Growth was significantly greater also for the trees under one-third and one-half radiation intensities when compared with growth under two-thirds and full sunlight. For a three year period the increase in growth under one-third and one-half radiation was 718 and 628 centimeters in height, 498 and 418 centimeters in branch spread and 14.10 and 12.98 centimeters in trunk diameter, respectively. For two-thirds and full sunlight the increase in height was 577 and 498 centimeters, 343 and 209 centimeters in branch spread and 10.82 and 11.16 centimeters in trunk diameter, respectively. (Table 2).

According to the differences necessary for significance, the yields were practically the same under one-third and one-half solar radiation. Growth in height and trunk diameter was significantly greater under one-third radiation than under other treatments. The growth condition and general appearance of the coffee trees under the various exposures offered contrasting differences as noticed in figure 3. The trees under one-third and one-half solar radiation were very healthy and the leaves were of a normal green color, thin, shiny and tender. The development of internodal length was normal and comparable to that of trees growing under natural conditions. The difference in yields between treatments under one-third and one-half sunlight radiation was 4.64 pounds while the quantity needed for a difference statistically significant was 8.08. Therefore, there was no statistical difference between yields under these two radiations. (Table 2). In relation to growth, the difference for significance is greater than that actually obtained in the case of branch spread and trunk diameter attained under both treatments. The difference between branch spread of one-third and one-half sunlight was 80 centimeters and

TABLE 2. *Yields in pounds and growth increases of coffee trees for a three year period.*

TREATMENT	YIELDS			GROWTH INCREASE 3-YEAR PERIOD			AVERAGE YIELDS 3 CROPS
	1938	1939	1940	HEIGHT	BRANCH SPREAD	TRUNK DIAMETER	
				CM.	CM.	CM.	(LBS.)
None - full sunlight	10.97	11.11	5.82	498	209	11.16	9.29
Two-thirds sunlight	15.26	23.66	12.12	577	343	10.82	17.00
One-half sunlight	19.99	34.41	18.04	628	418	12.98	24.13
One-third sunlight	23.64	45.96	16.76	718	498	14.10	28.77
Difference necessary for significance	10.18	21.09	9.05	46.57	92.47	1.17	8.08
Difference necessary for high significance	15.42	31.95	13.80	70.54	140.08	1.77	12.27

TABLE 3. *Yields and growth increases of coffee trees under the various ecological factors measured.*

TREATMENTS	YIELDS	SOLAR RADIATION	HEIGHT	BRANCH SPREAD	TRUNK DIAMETER	TEMPERATURE	RELATIVE HUMIDITY	SOIL MOISTURE
	POUNDS	KGR. CAL./ CM^2/YEAR	CENTIMETERS	CENTIMETERS	CENTIMETERS	°F	%	%
A— Full sunlight	10.97	134.90	131	111	2.3	73.26	64.74	24.17
	11.11	158.08	209	130	4.3	76.14	63.25	23.81
	5.82	141.27	237	133	4.8	76.20	60.00	23.86
B— 2/3 sunlight	15.26	76.54	145	137	2.7	72.49	62.22	25.35
	23.66	83.68	236	172	4.4	74.84	63.16	23.92
	12.12	77.63	264	172	4.9	75.10	60.20	24.73
C— 1/2 sunlight	19.99	54.48	147	149	2.9	70.51	65.31	25.44
	34.41	53.37	245	194	5.0	72.76	66.16	25.42
	18.04	51.56	280	201	5.6	73.20	65.50	23.78
D— 1/3 sunlight	23.64	29.60	143	153	3.1	68.80	77.58	26.82
	45.96	34.57	295	213	5.2	71.94	79.54	25.99
	16.76	32.69	296	229	5.5	71.70	75.20	25.73

a difference of 92.47 cms. was necessary for results to be significant. The significant difference required between trunk diameter under both radiations was of 1.7 and that actually obtained was of 1.12.

The trees under two-thirds and full solar radiation, specially the latter, were sickly and stunted. The leaves were underdeveloped, greenish and yellow, coriaceous, and dull. Internodal length was considerably reduced. The internodes were also greenish yellow and thin. The berries produced were smaller than those under shade and with a smaller quantity of mucilaginous substance.

Other Ecological Factors

Several environmental factors such as air temperature, relative humidity and soil moisture were recorded under the various solar radiation treatments.

The temperature fluctuations recorded lie between 68.80 and 76.20°F. Relative humidity fluctuated between 60.00 and 79.54 per cent. Soil moisture was the least variable, fluctuating between 23.78 and 26.82 per cent. Solar radiation ranged from 29.60 to 158.08 Kgr. cal. per square centimeter per year.

Solar radiation was found negatively correlated with yields and growth. Table 4 gives the correlation between yields and growth and the ecological factors recorded.

Solar radiation was negatively correlated with yields ($r = -0.64$) showing that increase in solar radiation intensity resulted in a decrease in yield. It was also negatively correlated with growth expressed as height, trunk diameter and branch spread.

Increases in height, branch spread and trunk diameter resulted in increases in yields and these were positively correlated as expressed by the corresponding results: $r = +0.78$; $r = +0.85$ and $r = +0.71$ for height, branch spread and trunk diameter respectively.

Temperature, relative humidity and soil moisture were influenced by solar radiation. These factors, were thought to be related to growth of coffee.

Temperature was positively correlated with increases in height and trunk diameter and negatively correlated with yields and branch spread. That is, lower temperatures were associated with higher yields and greater branch spread.

TABLE 4. *Correlation of yields and growth of coffee with solar radiation, temperature, relative humidity and soil moisture.*

FACTORS STUDIED	CORRELATION FACTOR (R)	CALCULATED SIGNIFICANCE	VALUES AT PH = .05	TABLES AT P = .01
Solar radiation and yields	—0.64 xxx	3.43	0.70	3.16
Solar radiation and growth in height	—0.20 xx	0.64	0.70	3.16
Solar radiation and growth in branch spread	—0.35 xx	1.18	0.70	3.16
Solar radiation and growth in trunk diameter	—0.38 xx	1.29	0.70	3.16
Growth (height) and yields	+0.78 xxx	4.66	0.69	2.97
Growth (branch spread and yields)	+0.85 xxx	6.11	0.69	2.97
Growth (trunk diameter) and yields	+0.71 xxx	3.77	0.69	2.97
Temperature and yields	—0.46 xx	1.63	0.70	3.16
Temperature and growth in height	+0.32 xx	1.06	0.70	3.16
Temperature and growth in branch spread	—0.25 xx	0.82	0.70	3.16
Temperature and growth in trunk diameter	+0.30 xx	0.99	0.70	3.16
Relative humidity and yields	+0.63 xx	2.56	0.70	3.16
Relative humidity and growth in height	+0.10 x	0.31	0.70	3.16
Relative humidity and growth in branch spread	+0.55 xx	2.08	0.70	3.16
Relative humidity and growth in trunk diameter	+0.13 x	0.41	0.70	3.16
Soil moisture and yields	+0.47 xx	1.68	0.70	3.16
Soil moisture and growth in height	—0.08 x	0.25	0.70	3.16
Soil moisture and growth in branch spread	—0.08 x	0.25	0.70	3.16
Soil moisture and growth in trunk diameter	—0.08 x	0.25	0.70	3.16

xxx highly significant (P = .01)
xx significant (P = .05)
x not significant

Relative humidity was positively correlated with yields and branch spread, and apparently did not show any relationship to growth in height and trunk diameter.

Soil moisture showed some relationship to yields, and apparently was not correlated with growth.

Total sugars, phosphorous, potash, and nitrogen were generally found in greater quantities in the leaves of plants under full sunlight. Air dry and absolute dry basis analyses of the leaves for total sugars, phosphorous, potash and nitrogen (Table 5) showed that these substances were generally found in greater quantities, specially potash and nitrogen, in the leaves of coffee trees exposed to full sunlight.

Discussion and Summary

It is obvious that solar radiation is an influencing factor in the growth and yield of coffee; insufficient and excessive light both impair growth and yield.

Contrary to what was expected, soil moisture was found to be the least fluctuating of all factors. All plots showed practically the same content. It is probable that although the plots under full exposure were expected to be submitted to the greatest soil evaporation, the transpiration from these trees was much less due to the smaller leaf area. In the shaded plots the transpiration of the trees was much greater because of their larger area of leaf. In either case the evidence points to a greater importance of transpiration than evaporation.

Sunlight had a formative effect on the coffee trees. Trees fully exposed offered contrasting differences when compared to shaded coffee plants. Growth was checked in every respect in trees fully exposed. The leaves were considerably smaller in size, the internodes were shortened, the height of vertical shoots and the lateral spread of fruiting branches was reduced and the berries were smaller than those of trees under shade.

According to the results obtained, an average of 53,143.20 gram calories per square centimeter per year is the optimum cumulative solar radiation for coffee growing in Puerto Rico. These figures compare favorably with solar radiation obtained under natural shade of Guaba trees (*Inga Inga* Br.) spaced at 16 x 16 ft. and under ordinary cultural methods. Generally, the solar radiation admitted in commercial plantations is much less on account of the excessive number of shade trees.

The effect of solar radiation on coffee trees was due obviously to

TABLE 5. *Analyses of coffee leaves.*

SAMPLES FROM TREATMENT	AIR DRY BASIS				ABSOLUTE DRY BASIS			
	TOTAL SUGARS	TOTAL P_2O_5	TOTAL K_2O	NITRATE NITROGEN	TOTAL SUGARS	TOTAL P_2O_5	TOTAL K_2O	NITRATE NITROGEN
Full radiation ----------	3.63	0.44	1.95	1.22	3.89	0.47	2.09	1.31
2/3 radiation ----------	3.27	0.29	1.75	0.39	3.52	0.31	1.88	0.42
1/2 radiation ----------	3.89	0.41	1.74	0.80	4.31	0.45	1.93	0.89
1/3 radiation ----------	3.26	0.30	1.42	0.59	3.68	0.34	1.60	0.67

both the cumulative and the intensity of radiation. The full sunlight plots received in three years 434,263.20 gr. cal./cm.$_2$ and the maximum and minimum intensities were from 1.91 to 1.35 gr. cal./min./cm.^{2}. The plots under 1/3 exposure received in 3 years 96,291.54 gr. cal/cm.^{2}, and the maximum and minimum intensities fluctuated between 1. 45 and 0.81 gr. cal./ min./ cm.^{2}. (Table 1).

According to the records of solar radiation (Table 1), shade contributed to equalize the solar radiation received in the plots under 2/3, 1/2 and 1/3 exposure, since there was little annual fluctuation in the total amount of solar radiation received. Increase in solar radiation resulted in a decrease of both yield and growth of coffee. This agrees with results obtained with other plants, Gourley, Nightingale (5), Korstian (7), Shirley (13). No significant difference was obtained between the growth and yields of plants growing under one-half and one-third exposures. Under full exposure, the growth, yield and general appearance of the trees was absolutely inferior to those under one-half and one-third radiation. The leaves of trees under full exposure were smaller, dull-colored and chlorotic.

The various ecological factors measured were correlated with yield and growth (Table 4) and as a result, solar radiation was found to be negatively correlated with yield and growth, thus as solar radiation increased, growth and yield decreased. Growth and yield were positively correlated, that is, greater growth resulted in greater yield. Temperature and yield were negatively correlated and this has been found to be true from observation. In Puerto Rico the greater yields of coffee have been obtained in the regions with lower temperatures. Temperature was found to be positively correlated with height, which according to observations is the general trend in Puerto Rico, vegetation being more luxuriant at lower elevations where the temperature is higher. Relative humidity was positively correlated with yields but apparently was not correlated with height.

Under full radiation the accumulation of potash and nitrogen was greater and that of phosphorous lower than in the shade (Table 5). This suggests that these relations be studied carefully to determine if plants when fully exposed utilize more nitrogen and potash than when shaded.

Conclusions

In this study, four ecological factors were observed: solar radiation, air temperature, relative humidity and soil moisture. Of the four, solar radiation fluctuates more than any other and undoubtedly the other three factors are influenced by solar radiation to a great extent.

1—Solar radiation varies widely with season and year.

2—The greatest intensity takes place during the months of June to September and the lowest from November to February.

3—The greatest intensity recorded under full sunlight was 1.91 gr. cal./ min./ cm.^{2} and the lowest was 1.35 gr. cal./ min./ cm.^{2}.

4—The yearly average solar radiation under full sunlight was 144,754. 40 gr. cal./ cm.^{2}.

5—The cumulative radiation for the 3 years that lasted the experiment was 434,263.20 gr. cal./ cm.^{2}, under full sunlight.

6—Shade regulates solar radiation making it more uniform from one year to the other.

7—As solar radiation increases, growth and yield of coffee decrease.

8—Yield and growth of coffee were definitely higher under 1/2 and 1/3 than under 2/3 and full sunlight.

9—Statistically significant differences in yield were not found between plots with 1/2 and 1/3 sunlight. Growth was significantly higher under 1/3 exposure.

10—Radiation produces distinctive formative effects on coffee. Plants under full sunlight were very weak, chlorotic and poorly developed.

11—Four ecological factors were measured: solar radiation, temperature, relative humidity and soil moisture. All are affected by radiation to a great extent, but other factors as vegetation have also some effect.

12—Solar radiation is negatively correlated with yields and growth.

13—Growth and yields are positively correlated. As expected low temperature and yield are associated and soil moisture acts independently in relation to growth.

14—Plants under full sunlight accumulated greater amounts of nitrogen and potash and to a less extent of phosphorous than under any other exposure.

15—An average of 53,143.20 gram calories per square centimeter per year is the optimum cumulative solar radiation for yield and growth of coffee. This amount is obtainable under natural shade of Guaba trees (*Inga Inga*) planted at not less than 16 x 16 feet.

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Sumario

1—La radiación solar varía grandemente con los años y las estaciones.

2—La mayor intensidad se registra generalmente entre los meses de junio y septiembre mientras que la menor intensidad ocurre entre los meses de noviembre y febrero.

3—La mayor intensidad registrada fué de 1.91 calorías-gramos por centímetro cuadrado por minuto, y la menor fué de 1.35.

4—A pleno sol la radiación media anual fué de 144,754.40 calorías-gramos por centímetro cuadrado.

5—La radiación solar total por los tres años que duró el estudio fué de 434,263.20 calorías-gramos por centímetro cuadrado.

6—Aparentemente la sombra regula la radiación solar haciéndola más uniforme en el transcurso de los años.

7—A medida que la radiación solar aumenta, el crecimiento y la producción de los cafetos disminuyen.

8—El crecimiento y la producción de los cafetos fué superior bajo exposiciones solares de una mitad y de un tercio.

9—No hubo diferencias significativas en producción entre los tratamientos bajo exposiciones de un tercio y una mitad de luz solar. Hubo, no obstante, diferencia significativa en crecimiento entre los tratamientos bajo un tercio y una mitad de luz solar siendo mayor el crecimiento bajo un tercio.

10—La radiación solar produce marcados cambios en la morfología de los cafetos. Cuando éstos están bajo plena luz solar, son tan mediocres en crecimiento y sus hojas y tallos adquieren tales características que dan la apariencia de ser una variedad distinta a la que se obtiene bajo sombra.

11—Cuatro factores ecológicos fueron estudiados; temperatura, humedad relativa del aire, humedad del suelo y radiación solar. Este último es el que más afecta el desarrollo del cafeto y afecta marcadamente los otros tres factores.

12—La radiación solar y la producción y el crecimiento están negativamente correlacionados. Esto es, mientras la radiación solar aumenta, la producción y el crecimiento disminuyen.

13—El crecimiento y la producción están positivamente correlacionados, como era de esperarse a mayor crecimiento, mayor producción. La temperatura baja y la producción están aparentemente asociadas. La humedad del suelo está afectada no solamente por la radiación solar sino también por la vegetación de las plantas que la cubren.

14—Las plantas bajo pleno sol acumularon en las hojas mayores cantidades de nitrógeno y potasa que bajo las otras exposiciones. Hubo además, acumulación de fósforo, pero en menor cantidad.

15—De acuerdo con los resultados de este estudio una radiación solar media anual de 53,143.20 calorías-gramos por centímetro cuadrado es la óptima para el mejor crecimiento y producción del cafeto. Esto es posible lograrlo bajo sombra natural de árboles de guaba, (*Inga Inga*) sembrados a no menos de 16 x 16 pies.

LITERATURE CITED

(1) Bates, C. G. The relative light requirements of some coniferous seedlings. Jour. For. **23**: 869-879. 1925.

(2) Briggs, L. J., and H. L. Shantz. Daily transpiration during the normal growth period and its correlation with the weather. Jour. Agric. Res. **7**: 155-212. 1916.

(3) Garner, W. W., and H. A. Allard. Effect of the relative length of day and night and other factors of the environment on growth and reproduction in plants. Jour. Agric. Res. **18**: 553-606. 1920.

(4) Gourley, J. H. The effects of shading some horticultural plants. Amer. Soc. Hort. Sc. **17**: 256-260. 1920.

(5) ————————, and G. T. Nightingale. The ffects of shading. New Hampshire Agric. Expt. Sta. Tech. Bull. 18: 1-22. 1921.

(6) Hartley, Carl, T. C. Merrill and Arthur S. Rhoads. Seedling diseases of conifers. Jour. Agric. Res. **15**: 521-558. 1918.

(7) Korstian, C. F. Some ecological effects of shading coniferous nursery stock. Ecology **6**: 48-51. 1925.

(8) Lubimenko, W. Production de la substance seche et de la chlorophyllien chez les végétaux supérieurs aux différentes intensités lamineuses. Annales Sci. Nat. Bot. **9**: 321-415. 1918.

(9) McClelland, T. B. Coffee shading. *In* Report P. R. Agric. Exp. Sta. **1934**: 12. 1934.

(10) ————————, and J. Guiscafré Arrillaga. Excess of shading diminishes coffee yields. *In* Report P. R. Agric. Exp. Sta. **1935**: 21. 1935.

(11) Popp, H. W. Effects of light intensity upon soybeans. Bot. Gaz. **82**: 306. 1926.

(12) Shantz, H. L. Effects of artificial shading on plant growth in Louisiana. U. S. Dept. Agric. Bur. Pl. Ind. Bull. 279: 32. 1913.

(13) Shirley, Hardy L. Influence of light intensity and light quality upon the growth of plants. Amer. Jour. Bot. **16**: 354-390. 1929.

A NEW SPINNING MITE ATTACKING SUGAR CANE IN PUERTO RICO

By E. A. McGregor, U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine.

Several lots of a mite have been received from Puerto Rico, where it is said to cause some damage to sugar cane. This mite proves to be new and is described as follows:

PARATETRANYCHUS SACCHARI, NEW SPECIES

Female. Color yellowish-green. Body outline (viewed from above) more narrowly elliptical than with most species of the genus. Dorsal bristles 26, not arising from tubercles. A single perfect eye cornea on each side. Mandibular plate not noticeably notched anteriorly. "Thumb" of palpus thicker than long, bearing at its tip a terminar "finger" whose greatest thickness is about two-thirds that of "thumb" at tip; terminal "finger" four-fifths as thick as its length, barely spatulate in profile; on upper distal angle of the "thumb" are two pin-shaped digituli; from near the middle of the upper face of the "thumb" arises a sensilla which is slightly longer than the terminal "finger" and is thicker than usual; a short hair arises immediately behind the dorsal sencilla, and a strong seta arises dorsally from the "thumb" near its base; a hair arises from near the middle of the ventralface of the "thumb". Claw on antepenultimate joint of palpus hardly reaching dorsal sensilla. Forelegs (adult female) barely more than one-half length of body (to tip of mandibular plate). Relative lengths of joints of leg I as follows: Trochanter 9, femur 29, patella 14, tibia 16, tarsus 29. Tip of tarsus bearing a strong, simple claw which is not much bent at any point; arising ventrally from near the base of the main tarsal claw are six straightish spurs which are considerably exceeded in length by the main claw; the usual four tenent hairs are present, a pair arising at each side of the claw base. Collar trachea extending backward as a straightish tube, the inner end barely enlarged.

Male. Length and width of body much less than in female. Forelegs

portionately longer than in female. Penis with inner lobe rodlike, in profile expanding extremely abruptly at its point of fusion with the shaft; dorsal basilar lobe present in the form of a prominent, sharply rounded protuberance; shaft with greatest thickness almost equal to its length, narrowed very abruptly posteriorly and bent upward and forward more than 90 degreess from its main axis in the form of a slender hook; the hook in turn is bent sharply backward and downward, terminating in a sharp point; profile of shaft and hook together resembling that of the forebody, neck and head of a swan.

Type slides. Cat. No. 1422, United States National Museum.

The type material is from Mayagüez, Puerto Rico, April 21, 1939, from sugar cane, collected by H. K. Plank. This mite was subsequently received from G. N. Wolcott, who collected it from sugar cane, sorghum, and a grass. Regarding this mite Doctor Wolcott writes that it seems to be of increasing importance in Puerto Rico. The first occurrences were noted on the cane variety Mayagüez 28, but it has since been observed on several other kinds of cane grown in Puerto Rico. Wolcott's first collection was made in a greenhouse on the Experiment Station grounds at Río Piedras, and subsequent collections were made at Loíza, Toa Baja, Dorado, Arecibo, Isabela, and Aguadilla, all in the northern part of the Island.

A second species of mite, *Paratetranychus viridis* Banks, (det. by Ewing) has also been reported from sugar cane in Puerto Rico.

In the male genital structure *Paratetranychus sacchari,* n. sp., is completely distinct from, and can hardly be likened to, any described mite. The penis is perhaps closest to that of *P. citri* McG., but in its other structural details bears no resemblance to this species. Zehntner's *Paratetranychus* (*Tetranychus*) *exsiccator,* from sugar cane in Java, is very distinct from the present species. *P. indicus* Hirts, which occurs on sugar cane in the Punjab, also appears to be distinct.

SUMARIO

UNA NUEVA ARÁCNIDA *(Paratetranychus sacchari McGregor)* ATACANDO LA CAÑA DE AZÚCAR EN PUERTO RICO.

Se describe una nueva arácnida (*Paratetranychus sacchari* McG.) atacando la caña de azúcar en Puerto Rico. Esta especie se describe como distinta de la otra especie *Paratetranychus viridis* Banks que también existe en la caña de azúcar en Puerto Rico.

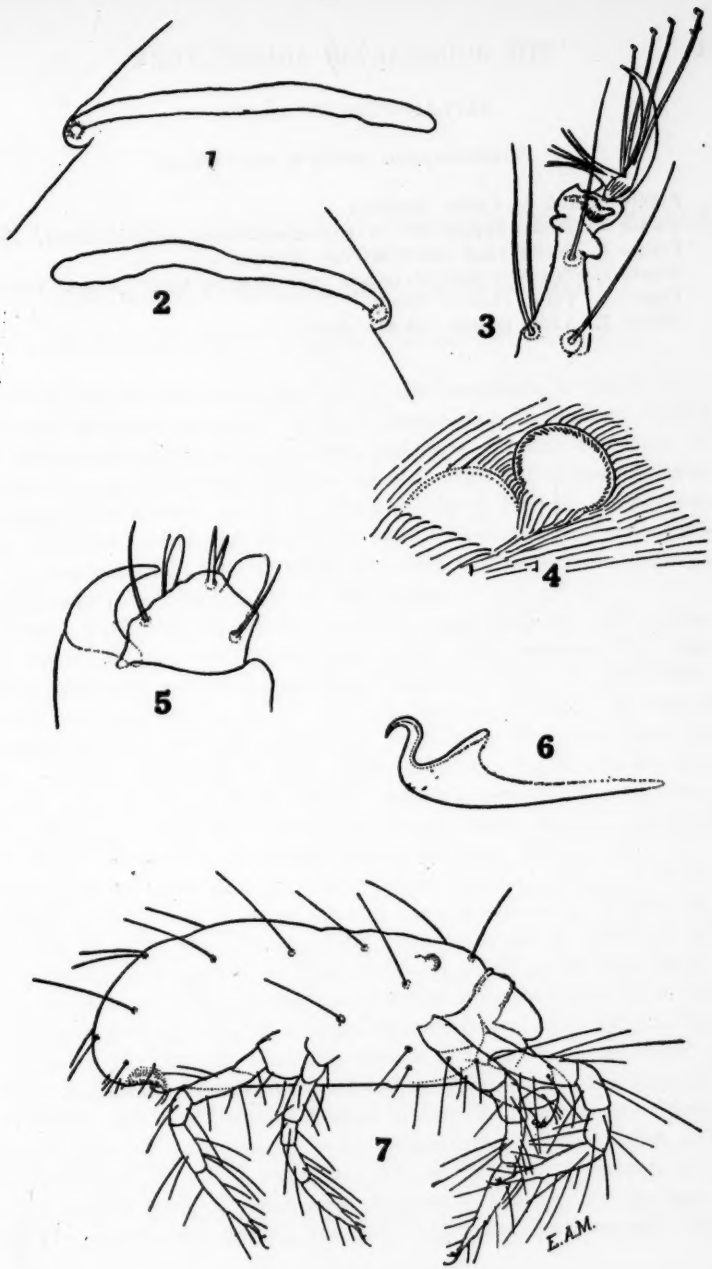

PLATE I. *Paratetranychus sacchari.*

EXPLANATION OF PLATE I.

Paratetranychus sacchari, NEW SPECIES

Figures 1 and 2. Collar tracheae.
Figure 3. Tarsal appendages of foreleg of female (lateral view).
Figure 4. Perfect and imperfect eye corneae.
Figure 5. Tip of palpus of female and its appendages (lateral view).
Figure 6. Penis (lateral view).
Figure 7. Adult female (lateral view).

THE OCCURRENCE OF A RARE GENUS OF TICKS ON BATS IN PUERTO RICO (ACARINA: SPELAEORHYNCHIDAE)

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Since bats are the only living native land mammals of Puerto Rico, the author attempted a survey of their ectoparasites in hopes of finding new, indigenous species of mites, ticks, and fleas. During the course of this work it was discovered that the common fruit eating bat, *Artibeus jamaicensis jamaicensis* Leach is parasitized by a tick in the unusual genus *Spelaeorhynchus,* not previously known to occur in Puerto Rico. No tick has heretofore been reported from bats in Puerto Rico, although previous efforts had been made to find them.

Over a period of six months excursions were made to various localities where bats were collected from caves. On February 21, 1942 fourteen bats were shot in a cave near Bayamón, which on examination revealed two specimens of ticks. A week later, on February 28, eleven specimens of bats from the same cave yielded one tick, and again on March 7 twelve bats from the same cave yielded two ticks. All the bats were the common fruit eating species, *Artibeus jamaicensis jamaicensis* Leach, which according to Anthony (1) is the most widely distributed of the Puerto Rican bats, its range covering the whole Island. This same species of bat had previously been collected at Lares (four specimens on November 4, 1941) and at Aguas Buenas (two specimens on October 12, 1941) but no ticks were found. Tate (10) collected 27 specimens of bats, including this species, at three different localities on the Island, but found no ticks. From these data it would seem that the tick is not very common, perhaps being of seasonal occurrence and local distribution.

A search through the literature showed that the ticks represent a species in the unusual genus *Spelaeorhynchus.* This genus is the only one in its family and is of peculiar interest because its members are closely related to mites and are thought to be an intergrade between mites and ticks (Ewing: 3, 4). This genus was first described by Neumann (7), the type species being *S. praecursor* Neumann, described at the same time. The correct type locality was later designated by Neumann (8)

as Pernambuco, Brazil. In 1902 Oudemans (9) established the family Spelaeorhynchidae for the reception of this genus. In 1917 another species was described by Banks (2) from the Canal Zone, Panama, under the name of *S. latus*. These two species constitute the known members of the genus and Ewing (3) suggested that *S. latus* Banks might be a synonym of *S. praecursor* Neumann, but this idea has been refuted by Fonseca (5, 6) who has presented biological notes on *S. latus* as it occurs in Brazil.

Unfortunately, the five specimens collected by the writer in Puerto Rico are not mature and, therefore, a definite specific determination could not be made. A specimen was sent to Dr. H. E. Ewing of the U. S. Bureau of Entomology and Plant Quarantine who compared the specimen with the types of *S. latus* Banks and stated that it appeared to be a nymph of *S. latus,* but that he could not be sure in the absence of adults. Dr. Ewing suggested that the species be called *Spelaeorhynchus* (?) *latus* Banks.

In each case the ticks occurred in the lower part of the ear, one tick to an ear. In one instance an individual bat had a tick in each ear. The mouth parts were inserted well into the flesh and in general the parasite had a typical ticklike appearance. Of the five specimens collected one has been placed in the United States National Museum, Washington, D. C., another in the School of Tropical Medicine, San Juan, Puerto Rico, and the remaining three are in the private collection of the writer. Unfortunately, the writer has been forced to discontinue work on this project, and it is hoped that someone else will take it up with the aim of finding adult specimens and working out the life history, which doubtless will be of great interest.

Tate (10) recorded five species of ticks from Puerto Rico, all of which represent introductions. The species reported herein brings the number to six and is of special interest because it seems to be an indigenous species occurring on one of our common native mammals.

Thanks are due to Jorge Luis Vivas, Warren Cupprill and César Segarra, students of the writer, who helped with the laborious work associated with field trips into mountains and caves.

SUMARIO

LA EXISTENCIA DE UN GÉNERO RARO DE GARRAPATA EN LOS MURCIÉLAGOS EN PUERTO RICO

El autor descubrió una nueva garrapata del género *Spelaeorhynchus*

como parásito del murciélago *Artibeus jamaicensis jamaicensis* Leach. Debido a la escasez de especímenes el autor no pudo hacer una determinación de la especie aunque no existe duda en su mente de que la garrapata encontrada sobre el murciélago es distinta a todas las descritas en el género *Spelaeorhynchus* u otros géneros.

LITERATURE CITED

(1) Anthony, H. E. The indigenous land mammals of Puerto Rico, living and extinct. Amer. Mus. Nat. Hist. Mem. **2**: 333-435. Illus. 1918.

(2) Banks, N. New mites, mostly economic. Ent. News **28**: 193-199. Illus. 1917.

(3) Ewing, H. E. A manual of external parasites, 225 pp. Illus. Springfield, Ill. and Baltimore, Md. 1929.

(4) ————. The orders and superfamilies of Acarina. Helminthol. Soc. Wash. Proc. **1**: 64-66. 1934.

(5) Fonseca, F. Notas d acareología. Localizacao, frequencia, distribucion geographica e hospedadores de *Spelaeorhynchus latus* Banks. Butantan Inst. Mem. **9**: 145-148. 1935.

(6) ————. Remarks on the tick *Spelaeorhynchus latus* Banks. Internatl. Cong. Zool. Proc. **12**: 1580-1582. 1937.

(7) Neumann, L. G. *Spelaeorhynchus praecursor*, n. gen. n. sp., nouvel acarien parasite. Arch. Parasitol. **5**: 31-37. 1902.

(8) ————. *Spelaeorhynchus praecursor* Neum. (Pernambuco not Africa). Arch. Parasitol. **10**: 220. 1905.

(9) Oudemans, A. C. Fam. Spelaeorhynchidae. Tijdsch. Ent. **45**: 55. 1902.

(10) Tate, H. D. The biology of the tropical cattle tick and other species of tick in Puerto Rico, with notes on the effects on ticks of arsenical dips. Puerto Rico Univ. Jour. Agr. **25**: 1-24. 1941.

THE VALUE OF FILTER PRESS CAKE AS A FERTILIZER FOR VEGETABLE CROPS. PRELIMINARY TRIALS WITH TOMATOES AND CUCUMBERS

By Arturo Riollano

Filter press cake is normally a by-product from the sugar mills of Puerto Rico. In many cases the disposal of this refuse is a sort of a problem since its dumping is rather costly. In other cases, the filter press cake is used for fertilizing the sugar cane plantations where apparently good results have been obtained with it when utilized as a substitute for chemical fertilizers. Some sugar mills have enormous quantities of filter press cake that have been accumulated for several years near the premises of the factory. In one of these sugar mills visited by the author, the filter press cake dump covered an area of approximately four acres in extent and six to eight feet deep. Dumping in that place had been going on for the last ten years.

Samples of filter press cake from this dump were taken at various depths, namely, first 12 inches, 12 to 24 inches and 24 to 36 inches. For each depth, eight samples from different places of the dump were taken. Analyses were made from these samples through the courtesy of Dr. J. A. Bonnet, Chief of the Division of Soils, who made the following report:

As may be readily seen in these analyses, the water content of filter

TABLE I. *Analysis of Filter Press Cake.*

SAMPLES	DEPTH	ORIGINAL MOISTURE CONTENT %	pH	AIR DRY SAMPLES				
				H_2O %	P_2O_5 TOTAL %	P_2O_5 AVAIL. %	K_2O AVAIL. %	TOTAL N %
1	0-12"	54.45	5.5	12.76	3.83	.59	.02	3.13
2	12-24"	26.24	6.5	12.04	2.63	.66	.08	2.65
3	24-36"	29.83	6.7	12.96	3.49	.50	.17	2.72
Average						.58	.09	2.83

press cake is rather high, varying from 26.24 to 54.45 per cent in the samples taken. The air dry samples, however, were reduced to a uniform moisture content varying only from 12.04 to 12.96 per cent. The analyses for food nutrients, total and available, were made on basis of these air dry samples. Verbal information was obtained regarding the availability of the total nitrogen reported, to the effect that for practical purposes all this nitrogen was in available form. For the purpose of our trials with vegetable crops, we are considering only as important the following averages of available food nutrients in air dry samples of filter press cake: nitrogen 2. 83 per cent, P_2O_5 .58 per cent, and K_2O .09 per cent. The amount of potash contained is so small that it may be considered as negligible. In fact, in other samples that the author had sent for analysis in previous years, the potash content had been reported in the form of traces.

Trials with Tomatoes

The first preliminary trial with filter press cake was established at the Isabela Experimental Substation with tomatoes, variety "Marglobe", in the type of soil known as Coto Clay No. 20. Bonnet (1) has described the properties of this type of soil of which there are some 7,000 acres located at the northwestern section of the Island. Two treatments were tested, namely, one where filter press in its natural state was applied at the rate of 12 tons per acre plus 1,000 pounds of chemical fertilizer 8-10-15 and the other, where 1,000 pounds of the last named fertilizer were applied alone. The filter press cake as well as the chemical fertilizer

TABLE II. *The effect of filter press cake on the yield of tomatoes.*

Classification of fruit yield	Mean yield in cwts. per acre		Increase in per cent	Odds
	Treatment A 12 tons filter press cake plus 1,000 lbs. fert. 8-10-15	Treatment B 1,000 pounds fertilizer 8-10-15		
Large, above .3 pound	69.9	58.5	19.5	18:1
Medium, .2 to .3 pound	70.6	56.4	25.2	216:1
Small, less than .2 pound	16.8	15.6	7.7	2:1
Culls, unmarketable	21.3	15.7	35.6	151:1
Marketable fruit	157.3	130.5	20.5	48:1
Total, all classes	178.6	146.2	22.2	32:1

were applied in the furrow in both cases. Forty plants were used in each plot which measured 20 x 22 feet or approximately 1/100th acre. Each treatment was replicated eight times. The soil was prepared to be irrigated by the surface irrigation system commonly known as the Hawaii system. Upon harvesting the fruit was classified as follows: large, weighing above .3 pound; medium, weighing .2 to .3 pound; small, weighing less than .2 pound; and culls, or unmarketable fruit. Weighings for each treatment were recorded in pounds and tenths of pounds. A total of seven different pickings were made in this trial.

Results

The results of this preliminary trial are presented in detail in table II. Significance of differences in mean yields has been determined by calculating the odds for the z values of "Student's" table as modified by Love (3).

As may be observed in this table, there was always a tendency to increase yield when filter press cake was applied to the soil. However, summing up these results in the most practical way, that is, considering mean yields of marketable fruit, it may be seen that this increase amounted significantly to 20. 5 per cent. In other words, the application of 12 tons of filter press cake was responsible for a significant increase in yield of 1.34 tons of marketable tomatoes.

Trial with Cucumbers (*Cucumis sativus* L.)

Upon failing to continue the work with tomatoes due to a heavy infection of mosaic, a more elaborate test with filter press cake was established in the same type of soil with the variety of cucumbers known as "Early Fortune". Though compost manure is rather scarce in Puerto Rico and is seldom used with vegetable crops, it was also included in this test as a matter of comparison. Check plots without any fertilizing matter were not incorporated in the test because in previous trials conducted by the author these had resulted in complete crop failures. Twenty tons of filter press cake per acre or twenty tons of compost manure were added to the soil with various combinations of 200 pounds of NH_3 derived from sulphate of ammonia, 200 pounds P_2O_5 from superphosphate, and 200 pounds of K_2O from sulphate of potash. Filter press cake and compost manure were also applied separately and alone without any chemical fertilizer. In all, fourteen treatments with seven replicates each in randomized blocks were included in this trial.

TABLE III. *The fertilizing value of filter press cake for cucumbers. (Yields on basis of all classes of fruit).*

NUMBER OF TREATMENT	FILTER PRESS CAKE	COMPOST MANURE	NH_3	P_2O_5	K_2O	MEAN YIELD IN CWTS. PER ACRE (1)
	(*tons*)	(*tons*)	(*pounds*)	(*pounds*)	(*pounds*)	
12	20	0	200	200	200	140
9	20	0	200	200	0	134
5	0	20	200	200	0	126
11	20	0	0	200	200	126
10	20	0	200	0	200	125
14	20	0	0	0	0	118
4	0	0	200	200	200	116
7	0	20	0	200	200	116
8	0	20	200	200	200	115
6	0	20	200	0	200	109
13	0	20	0	0	0	107
1	0	0	200	200	0	103
2	0	0	200	0	200	80
3	0	0	0	200	200	78

(1) Differences in yield greater than 22.2 are significant with odds 19:1.

Plots measured 1/80th of an acre and there were 107 cucumber plants in each plot. The soil was prepared in such a way as to facilitate surface irrigation whenever necessary. The different fertilizing materials were applied in the furrow 12 days before planting cucumbers. A total of 12 pickings were made during a harvesting period of 29 days. Fruit was classified according to the U. S. Standards and weighings were recorded in pounds and tenths of pounds.

Results

The results of this trial are shown in detail in table III. Though fruit was classified according to the U. S. Standards, results have been presented in total yield of all classes because a good correlation was found to exist between both. Yields from each treatment have been presented in the form of hundred-weights per acre. Significance of results has been determined by Fisher's (2) method of statistical analysis.

The 14 different treatments are subject to numerous comparisons,

but a few will suffice to demonstrate the high fertilizing value of filter press cake for cucumbers. Upon comparing treatments 14 and 4 it can be observed that an application of 20 tons of filter press cake alone produced 118 hundred-weights of cucumbers per acre, while the application of the complete chemical fertilizer alone produced 116 hundred-weights of fruit. Thus, it seems that the filter press cake can be a reliable substitute for chemical fertilizers. Furthermore, when the filter press cake and the complete chemical fertilizer were applied together, the yield was augmented significantly to 140 hundred-weights per acre as shown in treatment 12. In all cases filter press cake plus chemical fertilizers, complete or incomplete, caused an increase in yield when compared with complete and incomplete fertilizers alone. Compost manure, in general, ranked lower than filter press cake as an organic fertilizer.

Incidentally, a comparison of treatment 1, 2, 3, and 4 gives a strong indication that the type of soil Coto Clay No. 20 is markedly deficient in available NH_3 and P_2O_5. However, the requirements for K_2O are not high. In fact, the next highest yield or probably the most profitable application for the grower, was obtained with treatment 9, when 20 tons filter press cake, 200 pounds NH_3 and 200 pounds P_2O_5 were applied. This did not differ significantly from the highest yield obtained in treatment 12 where the filter press cake was applied with the complete chemical fertilizer. Bonnet (1) has also shown similar results with eggplants and cucumbers in regards to the availability of K_2O in this type of soil.

Summary

Filter press cake, a refuse from sugar mills in Puerto Rico can be used advantageously for fertilizing tomatoes and cucumbers grown in the soil type Coto Clay No. 20. When applied at the rate of 12 tons per acre plus 1,000 pounds of fertilizer 8-10-15 it caused a significant increase in yield of marketable tomatoes amounting to 20.5 per cent over the treatment where chemical fertilizer 8-10-15 had been applied alone at the rate of 1,000 pounds per acre.

When 20 tons filter press cake were applied alone and with different complete and incomplete chemical fertilizers, also significant increases in yield of cucumbers were observed. The yield with 20 tons of filter press cake alone was equivalent to the yield obtained with a complete fertilizer having 200 pounds NH_3, 200 pounds P_2O_5 and 200 pounds K_2O.

Results seem to indicate that the most profitable treatment would be probably 20 tons filter press cake plus 200 pounds NH_3 and 200 pounds P_2O_5.

Sumario

El Valor de la Cachaza Como Fertilizante para Tomates. Ensayos Preliminares con Tomates y Pepinillos

La cachaza que se obtiene en las centrales azucareras puede emplearse ventajosamente como abono para tomates y pepinillos en el tipo de suelo Coto Arcilloso Núm. 20. Aplicado a razón de 12 toneladas por cuerda en adición a 1,000 libras de abono de la fórmula 8-10-15 produjo un aumento en producción de 20.5% en tomates por encima de la producción con el tratamiento de 1,000 libras por cuerda de la fórmula 8-10-15.

En pepinillos *(Cucumis sativus L.)* cuando se aplicaron 20 toneladas de cachaza por cuerda se obtuvo una producción semejante a la producción obtenida cuando se aplicó un abono conteniendo 200 libras de NH_3, 200 libras de P_2O_5 y 200 libras de K_2O. Hay indicios de que se obtiene la mejor producción de pepinillos mediante aplicación de 20 toneladas de cachaza y 200 libras de NH_3 y 200 libras de P_2O_5.

Literature Cited

(1) Bonnet, J. A. Chemical data of Puerto Rico soils. University of Puerto Rico Agr. Exp. Sta. Research Bul. 1: 3-53. 1941.

(2) Fisher, R. A. Statistical methods for research workers. Oliver and Boyd, London. 1936.

(3) Love, H. H. Application of statistical methods to agricultural research. The Commercial Press, Ltd. Changsha, China. 1938.

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